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OCEANOGRAPHY.—*Observations on ocean temperatures in the vicinity of icebergs and in other parts of the ocean.* C. W. WAIDNER, H. C. DICKINSON and J. J. CROWE, Bureau of Standards.

Thru the courtesy of the Navy Department an opportunity was afforded representatives of the Bureau of Standards to make observations on the temperature of sea water in the vicinity of icebergs and in the open sea with a view to obtaining information on the possibility of detecting the proximity of ice from temperature records.

The Bureau party embarked on the *U.S.S. Chester*, leaving Philadelphia on June 2, 1912, under command of Captain Decker. Mr. Crowe was subsequently transferred to the *U.S.S. Birmingham*, under command of Captain Hughes, and continued observations from June 19, until the return to the port of Philadelphia on July 11, 1912.

Temperature equipment. Some of the more important apparatus assembled for these experiments consisted of the following: (1) A surface electrical resistance thermometer, consisting of a flat coil of silk-covered nickel wire inclosed between copper sheets, and insulated by thin layers of mica. The resistance of the nickel coil was about 100 ohms. (2) Deep sea thermometers of the Negretti and Zambra type kindly loaned by the Bureau of Fisheries. (3) Several standard mercurial thermometers. (4) A Leeds and Northrup recorder, suitable for use with the resistance thermometers. This was kindly loaned for these experiments by the Leeds and Northrup Company.

All of the apparatus was carefully calibrated before leaving the laboratory. The surface thermometer was mounted with its flat face directly against the inner surface of the ship's $\frac{3}{8}$-inch plates, about 6 feet below the water line. Simultaneous measurements of temperature, made with a sensitive mercurial thermometer inserted in the water and with the surface thermometer and recorder mounted as above, showed that the sudden changes in sea water temperature were indicated by the recorder without any significant time lag. The suspended system of the D'Arsonval galvanometer of the recorder was so carefully balanced by the makers that the records were entirely unaffected by the rolling and pitching of the ship. As used, a change of 1°C. corresponded to a movement of the pen of 18 mm. on the record sheet. The displacement of the paper was about 60 mm. per hour.

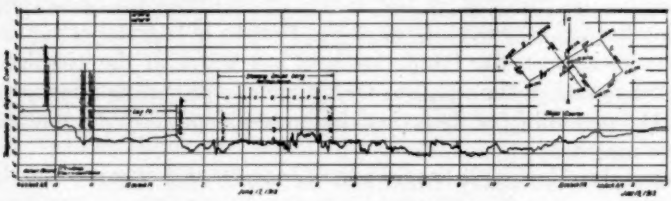

Fig. 1. Record of June 17, 1912

Temperature records. Practically continuous temperature records were obtained from June 4 until July 10, 1912. The temperatures recorded ranged from 3° to 25°C. The balance point of the recorder was changed to bring the temperature records on the paper by the insertion of suitable known resistances in one arm of the Wheatstone bridge circuit of the recorder, the calibration of the surface thermometer being made with the corresponding resistances in the circuit.

Figure 1 shows the temperature record obtained on board the *U.S.S. Chester*, June 17, 1912. Several small bergs or "growlers" were sighted on the horizon at 9.45 a.m. Almost simultaneously, the record shows a sudden fall of temperature from 8°.7 to 7°.3 C., or nearly 1°.5 C. At this time the ship was over 10 miles from the nearest of the growlers. The temperature continued to fall irregu-

larly as the growler was approached until 10.45 a.m. when the temperature was 5°.7C., at which time the distance from the growler, estimated by the range finder, was about 500 yards. At 11.00 a.m. the distance was about 150 yards. A party put out in a boat to take observations of temperature around the growler whose mass was estimated at about 12,000 tons. The surface temperature as determined by the observers in the life boat ranged from 5°.8 to 6°.7C.

At 1.20 p.m., the ship steamed toward a large berg about 12 miles distant. The course of the ship around this berg is shown by the diagram in the upper right corner of figure 1. The course *D* is 6 to 7 miles in length. The various legs of this course *A*, *B*, —*G* are also indicated on the temperature record, figure 1. No significance can be assigned to the irregular fluctuations of temperature observed around this berg (see figure 2).

About 5.25 p.m. the ship lay to, abeam of the berg at a distance of 300 yards. A party put out in a small boat for temperature observations. The time until about 7.00 p.m. was spent in the immediate neighborhood of the berg, the ship sailing around the berg, while the party in the small boat was taking observations. From about 7.00 to 9.30 p.m. the ship lay to, during which time the ship and berg drifted apart. The ship then cruised around until midnight in an unsuccessful effort to locate the berg with the aid of two powerful searchlights. From measurements made with two stadimeters, on the ship and on the whaleboat respectively, the mass of the berg was found to be about 400,000 tons.

The mean of a number of temperature observations taken from the whale boat gave the following surface temperatures: 20 feet from the berg 4°.5, 35 feet 4°.9, 50 feet 5°.0, 75 feet 5°.4, 200 feet 5°.7C. The temperature at a distance of 50 feet from the berg and at a depth of 5 fathoms was 3°.6C., and at a depth of 20 fathoms 3°.3. At some miles distant from the berg temperatures were encountered as low as those observed a few feet from the berg.

Variations in the salinity of sea water. Variation in the salinity of sea water in the neighborhood of icebergs due to the diluting action of the water resulting from the melting of the ice is so small as to be entirely masked by the accidental variations found

in sea water. The following determinations of the densities of samples of sea water, taken under conditions specified and afterwards tested in the laboratories, serve to illustrate this.

SAMPLE NUMBER	SPECIFIC GRAVITY AT $\frac{20°}{4°}$ C.	REMARKS
1	1.02339	Close to berg
2	1.02352	Close to another berg
3	1.02340	400 yards from berg
4	1.02336	40 miles from berg
5	1.02319	60 miles from berg
6	0.99923	Water from berg ice
7	0.99923	Distilled water

Echoes from icebergs. The testimony of numerous observers is on evidence that the echo of the fog horn may frequently, but by no means always, be detected when in the proximity of an iceberg or even of a bank of fog. The amount of evidence on this point leaves no doubt as to the correctness of the above statement. The experiment of sounding the fog horn when in the vicinity of a number of the bergs encountered on the trip was tried but in no instance was an echo detected. A few experiments were also made to determine whether an echo could be detected under water coming from the larger submerged portion of the berg. For this purpose the ship's bell was lowered into the water and signals produced by striking the bell. Observers stationed at the ship's submarine signal telephones listened for evidences of the echo. The ship was at a distance of 1 to 2 miles from the fair sized berg encountered by the *U.S.S. Chester* on the afternoon of June 17. It was difficult to draw postive conclusions on account of the disturbing noises present in the telephone receiver, but a number of observers were convinced that they heard faint echoes. There was no time to investigate and improve the telephonic apparatus, so that the most that can be said is that these preliminary experiments look hopeful enough to merit more careful experiments.

Other observations. The results of other experiments such as firing 3 and 5-inch shells into the berg, the utility of searchlights in locating bergs at night, etc., will undoubtedly be covered in the official reports of the commanding officers. It may be worth

while to record, however, the general impressions of the authors, unfamiliar with such matters, that the effects of cannon fire were disappointingly small and the utility of powerful searchlights surprisingly limited. Altho the lookouts were provided with spy glasses or with binoculars, it is of interest to note that the icebergs were invariably first seen with the unaided eye. The difficulty of picking up icebergs under some conditions is illustrated by the following incident. While the ship was steaming toward a large berg in sight, a heavy fog fell. One lookout was in the crow's nest, four were on the bridge, and two in the ship's eyes. Notwithstanding this the berg was first picked up from the quarterdeck after the ship had passed the berg some 200 yards abeam.

Samples of ice broken from the berg by gun fire were taken aboard ship. These contained considerable amounts of included air, which probably accounts for their white appearance. The ice was surprisingly hard and free from any definite cleavage planes. The whitish appearance was generally characteristic of all the bergs met with. In some instances there were narrow streaks of ice, transparent and of a blue color, that penetrated entirely thru the bergs.

The water resulting from the melting of the iceberg was found to have the same density as that of distilled water. It was free from any characteristic taste. So far as our observations go, the temperature of the air furnishes no evidence of value as to the proximity of a berg.

Discussion of observations. An examination of the temperature records which were obtained under a variety of conditions, in the region 37° to 43° 30′ north latitude and 43° to 53° west longitude, at once impresses one with the difficulty of separating the large and sudden variations of sea water temperature, so frequently met with, from any variations that may be caused by the proximity of icebergs. We have obtained records in some parts of the ocean in which the temperatures were practically constant to a few tenths of a degree for many hours. On the other hand, some of the records show that the temperature variations in other parts of the ocean, where no ice is near, are as great and as sudden as any observed in the neighborhood of

bergs. Having established the existence of such variations in sea water temperatures, it follows that it will be very difficult and often impossible to draw definite conclusions as to the proximity of ice from temperature records.

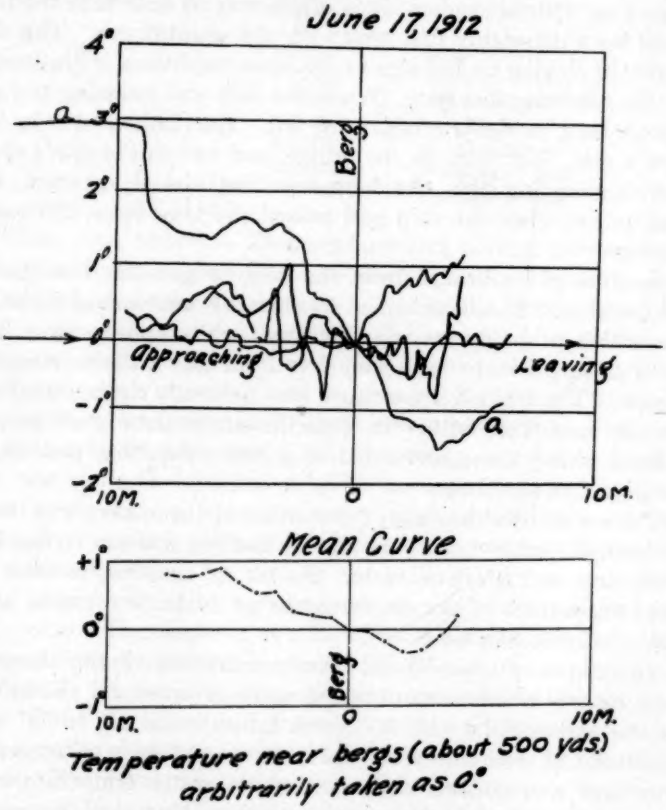

Fig. 2. Temperature about an iceberg

In approaching or leaving a berg the temperature of the sea water may rise or fall or remain practically constant. In figure 2, the temperature records of figure 1 are reproduced, the temperature at the iceberg being arbitrarily taken as the zero of temperatures for each course. Curve a, figure 2, is the temper-

ature record in approaching and leaving a growler. The remainder of the curves in figure 2 are the records for all the courses around the large berg, shown in figure 1. The temperature records for the several courses differ so much that no certain effect can be attributed to the iceberg. The mean of the curves for all the courses is shown in the lower part of figure 2.

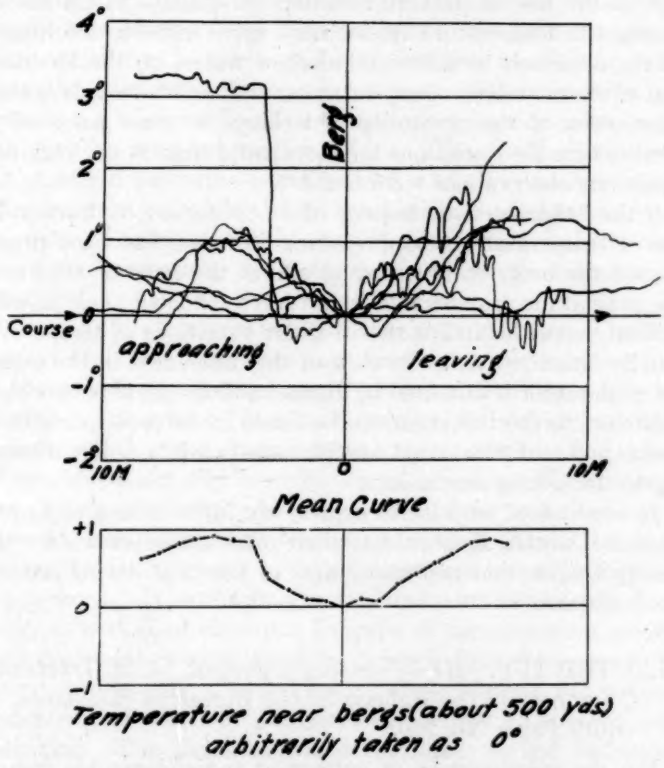

Fig. 3. Average temperature about several bergs

In figure 3 are reproduced all the temperature records, except those of June 17, for approaching and leaving icebergs, the temperatures at the bergs being always arbitrarily taken as the zero of temperature. The mean curve shown below, indicates

that in general there was a fall in temperature of about 1° in 4 or 5 miles in approaching the various bergs. In all but two instances the minimum temperature was found near the bergs. So far as our records go, therefore, it does not seem possible to draw positive conclusions as to the absence or proximity of ice from the temperature records of sea water. This is not a condemnation of the use of suitable recorders on ships. As Barnes has shown, the temperature record may give valuable information on the approach to shore and shallow water, on the identification of characteristic ocean currents, and, as his records seem to show, even of the proximity of icebergs in some parts of the ocean where the variations are less erratic than in the regions in which our observations were made.

If the "characteristic iceberg effect" observed by Barnes, i.e., rise of temperature on approaching icebergs, had been present around the bergs observed by us and of the same or even much less magnitude, our records would have rendered such an effect evident, notwithstanding the irregular variations of temperature usually found to exist. In view of the differences in the character of the records obtained by Barnes and by us, it is very desirable that further observations be made in different parts of the ocean, and under as varied conditions as possible, before attempting to draw final conclusions.

In conclusion, we wish to express our indebtedness to Captain Decker, Captain Hughes, and their officers and crews for their hearty cooperation and many acts of kindness during our stay on shipboard.

ELECTRICITY.—*High-frequency ammeters.* J. H. DELLINGER. To appear in the Bulletin of the Bureau of Standards, Scientific Paper No. 206.

For the measurement of current at radiotelegraphic frequencies, about 50,000 to 2,000,000 cycles per second, it is general practice to utilize the thermal effect of the current. The electrodynamic effect of the current has not been very successfully utilized; because, when the wire is coiled up to form an electro-

dynamometer, conditions are favorable (impedance large and capacity large) for part of the current to flow thru the dielectric instead of the wire, in amount varying with the frequency. The superiority of the hot-wire ammeter and the modifications thereof, in high frequency work, is due to the simplicity of form which the portion of the circuit within the instrument may have, permitting a minimum of self-inductance and capacity. A single straight wire of very small diameter is the only form of ammeter circuit which can be taken as *à priori* reliable at all frequencies. When the instrument is required to carry relatively large currents, such a wire is not sufficient, and more than one elementary path must be provided for the current. The distribution of current among these paths is determined solely by the resistances, at low frequencies, while at high frequencies the inductances predominate. Consequently the current distribution and the readings of the instrument are likely to change as the frequency is varied.

There are three general types of ammeters in use for large currents of high frequency: (a) that employing wires in parallel, (b) the so-called unshunted ammeter in which a single wire has different portions of its length in parallel, and (c) the ammeter employing thin metal strips. Both experimental and commercial instruments of all these types were investigated, experimentally and theoretically. All types were found to be subject to errors at radiotelegraphic frequencies. This fact is of great moment, for the ammeter is the cardinal instrument in high frequency work. It is of value in measurements of resistance and power, as well as of current. In some of the ammeters investigated the readings were found to increase with increase of frequency, and in others to decrease. These changes are entirely independent of the thermometric method used to measure heat production. The thermometric device may depend on expansion, calorimetry, electric resistance, or thermoelectric effect.

The observations were made by passing high-frequency and low-frequency current successively thru the instruments. An instrument under test was always in series with an instrument which could be taken as standard, and the two were observed

simultaneously. Thus the ratio of indicated current at high and low frequency, for equal total current in the circuit, was obtained. The high-frequency current was generated by the oscillatory discharge of a condenser across a spark gap. The instruments were in a secondary circuit, loosely coupled to the primary, and consisting of an inductance coil, the instruments, and Leyden jars, in series. The chief source of accidental error in the observations was the slight unsteadiness of the current together with the differing lag of the indicating devices of the instruments.

From the dimensions and arrangement of the wires it was found possible to predict quantitatively the changes of reading of the wire instruments with frequency, while theoretical considerations also made it possible to predict qualitatively the performance of the strip instruments. It is an interesting coincidence that the changes of reading occur just in the range of radiotelegraphic frequencies. In some of the instruments, the current distribution was constant from low frequencies up to about 100,000 then underwent changes, and became constant for 1,500,000 and higher frequencies. Thus, in one sense, physically infinite frequency was practically attained. The order of agreement of calculation and experiment attained with these instruments is in itself one of the most interesting results of the investigation. It shows that calculations based on the formulas for self and mutual inductance of finite portions of a circuit are valid, to the observed degree of accuracy, for short lengths and for damped high-frequency oscillations.

In the case of the parallel wire ammeter, mutual inductances between parts, which had hitherto been supposed to be negligible, are the determining factor in the change of current distribution. In the so-called unshunted ammeter, the errors are chiefly due to the self-inductances of parts other than the hot wire. In this case, they can be minimized by symmetrical location of the current leads. In the strip ammeter, the terminal blocks have been found to be the source of large errors. These are reduced by proper shaping of the blocks.

One effective means of reducing the errors of these ammeters at high frequencies is by using working parts of high resistance,

i.e., metal wires or strips which are very thin and of high resistivity. Another expedient is to change the design so that the deflections depend on the entire heat production in the instrument instead of on that in one branch of its circuit. It was found possible to apply this idea to the thermocouple instruments, as well as to those whose indications depend on other thermometric principles. Still another method of improvement is to arrange the working parts (either wires or strips) as equidistant elements of a cylinder, so that each has the same set of mutual inductances. This design approaches as a limit the circular tube, which theoretically has no change of current distribution with frequency. In common with the others, however, it is subject to an error which has hitherto been overlooked. It is difficult to obtain very thin wires or strips of uniform cross-section, and this variation results in the resistances of elements being unequal while the inductances are substantially equal. As a result the current distribution may be uniform at high frequency and not at low frequency.

Eddy currents induced in neighboring masses of metal are found to cause no error. Inductive action of the leads near an instrument in some cases appreciably affects the readings, and must be guarded against. The distributed capacity of the circuits within the instruments is found to cause no error, but the capacity of auxiliary parts produces an appreciable effect at the highest frequency used, 1,500,000 cycles per second. This effect was very striking, two instruments in series carrying different amounts of current. Apparently part of the current was shunted out of one of the instruments by electrostatic induction. A means of eliminating the effect was found for the purposes of ammeter comparison. This phenomenon suggests that the current in a conducting circuit may not be a definite quantity at frequencies over 1,000,000.

In conclusion, it may be said that all types of ammeters in use for large currents of high frequency are subject to errors. The sources of error have been isolated and studied. Some were shown to be negligible, and others very serious. Means of improving the designs have been worked out.

CHEMISTRY.—*The interpretation of mineral analyses.*[1] ROGER C. WELLS, Geological Survey.

In a recent number of this Journal W. T. Schaller proposed an improvement in the usual method of reducing a mineral analysis to a chemical formula which seems to have some advantages.[2] A little later F. E. Wright and C. E. Van Orstrand published a paper on the determination of the order of agreement between observation and theory in mineral analyses in which they state that Schaller's method is in error in certain details of principle and discuss several methods of making comparisons between analytical data and theoretical formulas based upon the method of least squares.[3] Without doubt both of these papers represent certain advances, but as they stand there is too much variance between them. The subject is one of general interest and fundamental importance so that some further observations may not be inappropriate.

The excellent analysis of pearceite upon which the discussion in these papers is based was published some time ago by F. R. Van Horn and C. W. Cook.[4] At present only methods of comparing the analytical data with theory are in question. Van Horn and Cook obtained from their analysis the atom numbers of sulfur, arsenic and silver 10.80, 2.000 and 7.886 from which they easily deduced the correct formula, $8Ag_2S.As_2S_3$. The real question decided concerned only one atom in 15, that is between the formulas $9Ag_2S.As_2S_3$ and $8Ag_2S.As_2S_3$. The analysis was considerably more accurate than necessary to decide this point.

The improvement proposed in the calculation by Schaller is suggestive altho not essential to the evaluation in this case and consists in the use of an arithmetic mean instead of a single value of the greatest common divisor by which percentages found in an analysis are reduced to numbers of atoms. The details of carrying out this calculation may be found in his paper. He thus obtained the numbers 10.92, 2.02 and 7.97 which are closer to

[1] Published with the permission of the Director of the U. S. Geological Survey.
[2] Journ. Wash. Acad. Sci., **3**: 97. 1913.
[3] Journ. Wash. Acad. Sci., **3**: 223. 1913.
[4] Amer. Journ. Sci., (4) **31**: 518. 1911.

the whole numbers of the formula 11, 2 and 8 than the numbers above. Schaller also expressed the numbers in another form intended to show their variation from whole numbers more clearly as follows 11×0.993, 2×1.01 and 8×0.996. In this form deviations from the requirements of theory are shown as factors of the quantities involved.

Wright and Van Orstrand begin their discussion on page 224 as follows: "The underlying purpose of such calculations is not, however, to improve a chemical analysis by mathematical manipulation, which is obviously impossible, but to obtain a logical basis of comparison for the given analysis with the analysis calculated from the chemical formula." Unfortunately, while objecting to "mathematical manipulation" the authors of the second paper appear to have recommended and rejected methods of calculation on purely mathematical grounds entirely apart from any consideration of the necessary chemical relationships involved.

In the first method of calculation described they begin by inferring that the correct numbers are 11, 2 and 8. They then derive by the method of least squares a "weight percentage composition" (column 5) for comparison with the analysis which totals 99.84. In other words they present a basis of comparison that totals less than the original investigators obtained in their analysis, viz., 99.89, and conclude "the differences between the observed (y) and computed (y') values (o–c, column 1–5) are a proper measure of the degree of approximation of the actual analysis to that computed from the inferred chemical formula." Let us see how this works out. Assuming equal errors in all the percentages of an analysis of the mineral in question, say, 0.10, we come out of the comparison with the following differences: 0.05, 0.09, 0.05 and 0.08. In other words the chemist should have unequal errors in his percentages to obtain a perfect comparison! Now as a matter of fact he does have unequal errors in his percentages, and these errors are roughly proportional to the percentages involved. Working out the scheme on the assumption that the errors are the same fraction, say 1/200th of all the percentages gives no differences whatever. Obviously the more nearly all errors can be made proportional to the quantities of substance involved the better the comparison will turn out on the whole.

This leads us to the conclusion that "residual errors" or "differences" have very little meaning by themselves. This meaning can only be brought out by comparison with the magnitudes involved. For example an error of 1 gram in weighing 7 grams of arsenic is a very different order of error from that of 1 gram in 59 grams of silver. This is a general proposition but it has particular application in chemical operations where we are so frequently concerned with the numbers of atoms involved, the atoms having different weights. If we are to make equally good determinations of atomic quantities of two substances we must keep our *relative* errors not our *absolute* errors the same in the two determinations. So far as my experience in tracing the effects of errors upon the results in different chemical operations goes, I believe that the best policy for the chemist to pursue is to assume a given error in a measurement, carry thru the whole calculation and ascertain exactly what effect the error will produce in the final result. As is well known, relative errors in a magnitude are transmitted unchanged in multiplication and division of the magnitude by other magnitudes, but they are affected irregularly or may practically disappear in additions and subtractions.

The chemist well knows that in addition to "random" errors there are errors that depend on the elements involved and the methods used. For example, it is not difficult to determine silver with accuracy; the same cannot be said of arsenic. Sulfur is usually weighed as barium sulfate, a substance over seven times heavier than its equivalent of sulfur, while copper is frequently weighed as metal. Even if the same accidental error in milligrams is made in weighing these two substances the sulfur determinations will turn out to be seven-fold as accurate as that of the copper. Neglecting these special relations, however, it may be said that *errors will tend to be proportional to the magnitudes involved.* This relation does not hold strictly because the analyst usually allows himself a little more laxity in the case of the minor constituents and in these the "constant" errors attain more significance. *This difference in the nature of the errors is of fundamental importance in deciding upon methods of calculation and comparison.*

In the method employed by Van Horn and Cook one deter-

mination is assumed to be free from error and the remaining atom numbers show discrepancies from the requirement of theory. Schaller's method is a simple method of distributing the discrepancies. It occurred to Wright and Van Orstrand that the method of least squares would give a still better distribution of discrepancies. In the illustration worked out by them, however, (first method) it is obvious that the y values (observed data) are weighted by multiplication by the respective molecular weights (x values). It would be perfectly possible to weight the observation equations in any arbitrary manner. It would seem, however, that if the discrepancies are assumed to be random ones the weighting should be based upon the magnitude of the discrepancies rather than that upon the molecular weights involved. In view of what has been said it can be seen that the weighting should probably also vary with the mineral, the number of atoms, etc., so that the chief difficulty would be in getting chemists to agree upon a system of weighting.

There is some objection from a chemical point of view to any method involving a distribution of discrepancies. It must be borne in mind that a mineral may be a mixture, a solid solution, or a molecular species. All these possibilities occur in nature and some species occur in a state of remarkable purity. Yet it is hardly to be expected that natural products formed from, or open to attack by, migrating solutions of various kinds can be wholly free from inclusions of foreign matter. Under these circumstances a clear differentiation between fact and hypothesis should be preserved. An analysis is a more or less imperfect expression of certain facts, viz., the composition of the substance in question; that this composition may be expressed in a chemical formula is an hypothesis which may find only approximate verification in the case of a mineral. As our knowledge widens minerals are being found more and more to be solid solutions to a slight extent; these interesting relationships are brought out by independent derivations of the atom numbers but masked by a distribution of "errors." Methods involving a distribution of errors are therefore strictly applicable only to very pure compounds.

But in reverting wholly to a comparison of percentages we lose

some advantages possessed by a comparison of the atom numbers. Residuals of the latter may be compared with one another with respect to the possibility of their combination into simple molecules. In objecting to this method of comparison on mathematical grounds the authors of the second paper appear to have overlooked an important distinction. In weighing out the mineral for analysis as well as in all the analytical operations there are the same atoms involved, atoms of different weights—here eleven atoms of sulfur, two of arsenic and eight of silver—so that the percentages of the different elements are already weighed, i.e., "weighted" according to these proportions and, in dividing, the chemist simply tends to restore unit weight to each determination of the common divisor upon which the atomic theory depends. When we compare percentages we compare data for eleven atoms of silver, two of arsenic, and eight of silver; on the other hand, when the comparison is between different values of the greatest common divisor we are comparing numbers having a significance common to all the atoms in the mineral.

Now in view of the consideration on page 419 it appears in general that (a) when percentages are compared the principal constituents will contain the smallest relative errors while constant errors will tend to compensate one another. The total essential constituents expanded to 100 per cent will therefore be the best basis of comparison with the theoretical percentages. (b) When the atom numbers are to be compared the one obtained from the minor constituent will be most affected by "constant errors" such as those of weighing and measuring, the one obtained from the major constituent will be most affected by "relative errors," those proceeding from chemical transformations. Which kind of error will predominate here will depend again upon the mineral and the method of analysis. The plan has heretofore been to base the value of the common divisor upon the minor constituent. Schaller's proposal bases the divisor upon all the constituents. Another plan would be to base the value of the common divisor upon the chief constituent or the most accurately determined one. A factor may be *very simply obtained*, however, *by taking 1/100th of the molecular weight assumed for the mineral,*

which is obviously theoretically correct for each formula assumed.[5] It is then only necessary to multiply the combining ratios found, by this factor, to obtain the exact atom numbers found in the analysis.

The comparison of the analysis under discussion with theory may therefore be made by either of the two following methods:

FIRST METHOD

	PERCENTAGES FOUND	EXPANDED TO 100 PER CENT	THEORY FOR $8Ag_2S.As_2S_3$	ABSOLUTE DISCREPANCY	RELATIVE DISCREPANCY IN PER CENT
S.....	17.46	17.48	17.56	−0.08	−0.5
As.....	7.56	7.57	7.46	+0.11	+1.5
Ag.....	59.22	59.28	59.32[1]	−0.04	−0.1
Cu.....	15.65	15.67	15.66	+0.01	+0.1
	99.89	100.00	100.00	Mean ±0.06	Mean ±0.5

SECOND METHOD

	COMBINING RATIOS FOUND[2]	ATOM NUMBERS FOUND[4]	THEORY	ABSOLUTE DISCREPANCY	RELATIVE DISCREPANCY IN PER CENT
S.....	0.5451	10.95	11.00	−0.05	−0.5
As.....	0.1010	2.029	2.000	+0.029	+1.5
Ag[3].....	0.2748				
Cu[3].....	0.1233	8.000	8.000	0.000	0.0
				Mean ±0.02	Mean ±0.5

[1] Calculated from the combining ratios as follows: $16\times\left(\frac{0.2748}{0.3981}\right)\times 107.88$. Similarly for the copper. In the case of replacements such as that of copper for silver here the molecular weight assumed must be obtained by taking proper proportions of the atom numbers of the simplified formula. As the number of replacements increases, the more difficult it becomes to derive either a "theoretical" molecular weight or a theoretical percentage.

[2] Obtained from 17.48, etc., above by dividing by atomic weights.

[3] Considered as Ag_2 and Cu_2.

[4] Obtained from 0.5451, etc., by multiplying by $\left(\frac{2009.1}{100}\right)$ where 2009.1 is the molecular weight assumed.

[5] If M is the molecular weight assumed 1 per cent of M is $\frac{M}{100}$; if y per cent of an element has been found, the molecular portion will be $\frac{yM}{100}$ and this will be as many atoms as the atomic weight of that element is contained in $\frac{yM}{100}$ or $\frac{yM}{100A}$; hence the factor for each molecular ratio will be $\frac{M}{100}$.

If the arguments set forth in the preceding discussion are valid the relative discrepancies in the last columns are the best indices of the agreement of the data found with the formula assumed. To say that 10.95 has a discrepancy of −0.5 per cent from the theoretical value 11 is very similar to expressing 10.95 as $11. \times 0.995$. In my opinion the "mean relative discrepancy" is probably the best single value which can be found to indicate the order of agreement of a mineral analysis with the formula.

The principal conclusions in this paper may be summarized as follows:

1. "Differences" are not a good measure of concordance when comparisons are made between several numbers of different magnitude or where different chemical elements are concerned. The discrepancies should also be thought of as factors or percentages of the quantities involved.

2. Before a mathematical simplification in analytical data is attempted the nature of possible errors and their mode of transmission to the final result should be considered.

3. The analytical percentages of a mineral analysis will in general contain some random errors and will certainly contain errors characteristic of the individual elements. The errors will however tend to be proportional to the quantities of substance involved. If the chemist wishes to bring up the accuracy of all the constituents to their full measure in the determination of the whole mineral, he should devote his chief attention first to the constituent which he believes to be subject to the greatest absolute error and next to the other constituents in the order in which they occur by weight beginning with the predominating one.

4. Any method of comparing the analytical data with theory which involves a distribution of the discrepancies may mask some relations, such as those of solid solution or the presence of a free element and should therefore be used only in the case of pure compounds.

5. The percentage of the essential constituents found should first be expanded to 100 per cent and then compared directly with the theoretical percentages. Or the combining ratios found may be multiplied by the factor $\frac{\text{molecular weight assumed}}{100}$ and the atom numbers thus found compared with theory.

6. The "mean relative discrepancy" of all the determinations is probably the best single index of the agreement of a mineral analysis with a chemical formula.

CHEMISTRY.—*Note on the analysis of water from a deep well in Pennsylvania.* GEORGE STEIGER, Geological Survey.

The well from which the water was obtained is situated eight miles southwest of Imperial, Allegheny County, and five miles northwest of McDonald, Washington County, Pennsylvania.[1] Down to 6300 feet the well was perfectly dry; at this point water was encountered and finally filled the well to a depth of 3000 feet.

At the request of Dr. G. F. Becker, the Peoples Gas Company, owners of the well, collected two samples of five gallons each. One sample was sent to the laboratory of the Bureau of Mines at Denver for radioactive tests; the other was shipped to the laboratory of the U. S. Geological Survey for the general chemical analysis.

GRAMS PER KILOGRAM OF WATER

Fe	0.16	SO_4	0.05
Mg	2.48	Cl	161.80
Ca	25.19	Br	0.70
Sr	3.55*	I	
Ba	trace		
Na	64.55		263.64
K	5.16	Sp. G	1.211

112.5×10^{-11} grams of radium per liter.

Silicon, aluminum, titanium, phosphorus, manganese, lead, bismuth, and carbonic acid, were tested for and were found to be absent.

* Equivalent to 7.8 grams of $SrCl_2$ per liter.

This water contains about eight times the quantity of dissolved salts per kilogram as that of sea-water. When received, a quantity of suspended matter was present, probably finely divided rock introduced through the process of drilling. This was separated by filtration and the filtrate which was perfectly clear was used for analysis. Dr. Becker who will be assisted by Mr. C. E. Van Orstrand, in the near future, intends studying the well regarding temperature and radioactivity. It was in rela-

[1] A complete description of this well by I. C. White will be found in the Bulletin of the Geological Society of America, **24**: 273-282. 1913.

tion to the radioactivity that lead, bismuth, and barium were very carefully tested for.

When time permits drill cores of the accompanying rock will be analyzed in the hope of throwing some light on the source of the large strontium content; this metal being of rare occurrence in surface rocks of this locality. Dr. R. B. Moore who kindly made the determination of the radioactive matter states that the amount is not excessive for water of this character.

For the collection of the water the Survey is indebted to Mr. John G. Pew, Vice-President of the Company.

BOTANY.—*A new shrubby buckeye.* W. W. ASHE, Forest Service.

Aesculus microcarpa sp. nov. Leaves with slender glabrous petioles, much longer than the middle leaflet; mostly five obovate-oblong leaflets, which are sharply serrate, slender petiolulate, glabrous on unfolding except for minute tufts of hair in the axils of the veins; when mature glabrous, firm in texture and pale beneath; twigs slender, glabrous, glaucescent. Flowers, opening in Rabun County, Georgia, the last of April and early in May, about 3 cm. long, pale yellow or toward base orange, petals connivent, very unequal, puberulent, the claws puberulent; claws of lateral pair longer than calyx tube, the limb ovate or oblong; pedicels slender, mostly longer than the oblong-campanulate puberulent calyx tube. Fruit smooth, about 3 cm. thick, one-seeded, with thin, smooth reddish brown valves; seed spheroid, about 2 cm. in diameter. A shrub 1 to 3 m. in height. Growing with *Aesculus pavia* L. along rocky banks of streams and open red clay hills of western South Carolina and northern Georgia, between altitudes of 160 and 500 m. Type material which is in the herbarium of the author, is from Cherchero Creek, Rabun County, Georgia; it was collected in April and September, 1911.

This shrub is most closely related to *Aesculus octandra* Marsh, which grows with it along the upper edge of its distribution in Rabun County, Georgia. The flowers of the proposed species are about one-third larger than those of *Ae. octandra*, more slender, not so pubescent, the calyx more tubular, and the thyrse is smaller. The seed is solitary, spheroid, and about one-half the size of that of *Ae. octandra*.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*The determination of aqueous vapor above Mount Wilson.* F. E. FOWLE. Astrophysical Journal, **36**: 359. 1913.

The quantity of precipitable water existing in the form of vapor between the top of Mount Wilson and the outer limits of our atmosphere during fair weather from June to November, 1910, and 1911, was determined by the spectrobolometric method described in detail in the Astrophysical Journal, **35**: 149. 1912 (see this journal, **2**: 318. 1912). The average quantity present was 0.69 cm. and the range from 0.2 cm. to about 2.8 cm. of precipitable water. The difference in the monthly means would be small but for a few exceptionally moist days in August; almost the dryest day indeed for 1910 was August 13 (0.17 cm.) and the dryest for 1911, September 12 (0.12 cm.). A gradual but generally slow increase in atmospheric water vapor often took place during the observations which extended from about 7 a.m. to 10 a.m. This averaged 0.12 cm. For about 40 per cent of the days this increase was less than 0.1 cm.

These spectrobolometric results were then used in a study of the formula of Hann which, with a coefficient determined from balloon and kite observations, has been in use for connecting surface humidities with the quantity of aqueous vapor in the atmosphere. This coefficient was redetermined by means of the data above discussed. The general mean for the coefficients (1.8) agrees closely with that derived by Hann (1.9), also with that from Humphrey's data (1.7). The range of values is, however, so great (from 0.33 to 11.80) that we must regard the formula, though applicable for mean conditions, as of no value for individual days. F. E. F.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 724th meeting was held on April 12, 1913, at the Cosmos Club. President ABBOT in the chair; 55 persons present. The minutes of the 723d meeting were read and approved.

Mr. R. S. WOODWARD presented a paper on *The laws of falling bodies.* The history of the subject, beginning with the first consideration of the problem by Gauss and Laplace 110 years ago, was reviewed. These investigators differed in their conclusions, Gauss maintaining that there is a meridional deviation towards the equator, which Laplace denied. Poisson made some corrections to Gauss's work but accepted his conclusions, as did most of the subsequent workers. In view of conflicting opinions, differences in experiments, and of obvious defects in the memoirs, the speaker has thought it worth while to study the subject further, taking into account the recent work in geodesy. The method of Lagrange was used to derive the equations. The height of fall was limited so that there would be no exterior effects on account of other bodies. Discussion of equations was carried to terms of the second order and some results of the application of the formulae given. The conclusion reached was that the deviation in the meridional plane due to the rotations and figure of the Earth is towards the north. The easterly deviation is very much larger than the northerly. There is need of more information regarding the geodesy of the subject. The paper was discussed by Messrs. BAUER, LITTLEHALES, WEAD, and ROSA.

Mr. C. W. WAIDNER spoke on *Sea water temperatures in the vicinity of icebergs,* giving results of the experiments carried out by a party of three from the Bureau of Standards on a United States cruiser. The thermometer was a flat rectangular nickel coil enclosed between two copper plates pressed close to the side of the ship and connected to a Leeds and Northrup recorder. The equipment and charts showing some of the records were illustrated by lantern slides. So far as detection of proximity of icebergs is concerned, the general conclusion was that, while such records may be of help, the normal variations are generally so erratic and large in comparison with effect due to icebergs that it is practically impossible to get definite indications from the records. Other experiments made on salinity and density of sea water indicated that nothing could be accomplished, as the diluting effect is infinitesimal. The paper was discussed by Messrs. BAUER, LITTLEHALES, and BURROWS as to the radiation method from the surface of icebergs and by Mr. ABBOT.

J. A. FLEMING, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 512th meeting of the Biological Society of Washington was held on April 19, 1913 at the Cosmos Club, with Vice-President Hay in the chair and about 30 persons present.

HENRY TALBOTT exhibited an unusually large tooth of the fossil shark, *Carcharodon megelodon* from South Carolina and by way of comparison the much smaller teeth of Odontaspes from Chesapeake Beach, Maryland.

WELLS W. COOKE commented on the spring migration of birds, noting that this year the yellowthroat, redstart, wood thrush and catbird had arrived three days ahead of schedule time.

The regular program consisted of a communication by C. D. MARSH, on *Stock Poisoning by Larkspur*. He stated that ranchmen of the west had long claimed losses of stock due to larkspur, and on scientific inquiry had found their observations correct, and that the monetary loss was considerable. Altho larkspur occurs in other parts of the world it apparently only causes trouble in the Western United States. The average mortality in affected areas of the west is from 3 to 5 per cent, but as many as 20 head out of a herd of 200 have been fatally poisoned in twenty-four hours. The low larkspur appears to be always dangerous, but the tall only becomes so in August after the fruit matures. The poison is a cumulative one and requires from 3 to 10 per cent of the animal's body weight of larkspur plant to cause death or alarming symptoms. The symptoms consist of general discomfort, nausea, constipation, a characteristic arching of the back and sudden collapse, followed by partial recovery and a repetition of similar attacks, and if the case is a fatal one, to end in respiratory paralysis and death by asphyxia. Animals do not become immune to the poison. Horses may be experimentally poisoned but when feeding on the range do not eat into a patch of larkspur enough to consume a toxic quantity. Sheep are naturally immune to the poison and may be fed a continuous diet of little else than larkspur without showing any symptoms. The cowboy's treatment of the disease is bleeding but the proportion of recoveries by this method is not greater than in natural recovery. Rational treatment consists in placing the poisoned animal on sloping ground with head upward so that the abdominal viscera fall back from the thoracic organs. Drug treatment consists of eserin·pilocarpine and strychnine administered hypodermically. Under this method 96 per cent of poisoned animals recover. Alcohol is also effective but less practical. The paper was illustrated by lantern slides, showing the larkspur in detail and on ranges, and numerous animals in various stages of poisoning. The paper was discussed by Messrs. Bailey, Weed, Hitchcock, Gill, Lyon and others.

The 513th regular meeting of the Biological Society of Washington was held on May 3, 1913 at the Cosmos Club, with President Nelson in the chair and 56 persons present.

Dr. H. M. SMITH called attention to a large whale shark captured during the past year in Florida waters. It originally measured 38 feet in length, but as now mounted, 45 feet. Pictures of this shark were exhibited and extracts from a letter by the captor read. Dr. Smith's remarks were discussed by the chair and by Dr. Gill.

REGULAR PROGRAM

The remarkable extinct fauna of southern California revealed in the asphalt deposits near Los Angeles: Dr. C. HART MERRIAM.

The asphalt in this region was known to the Indians for centuries and was mentioned by the early Spanish padres. Altho remains of animals in the asphalt deposits have been known since about the middle of the last century, they have only lately been extensively studied by Dr. J. C. Merriam of the University of California. The viscous asphalt appears to have acted as a natural trap, first entangling certain birds and mammals, which in turn served as bait to larger predatory forms. The remains may be roughly divided into three groups: (1) Birds, some still existing, but mostly extinct, among them, hawks, eight genera of eagles, vultures, including both North and South American condors, a condorlike bird, *Teratornis* of huge size, owls, ravens, herons, a peacock; (2) Small mammals, as spermophiles, kangaroorats, etc., and small carnivorous forms as weasels, skunks, badgers, bobcats, grey foxes; (3) Large mammals, as deer, antelopes, buffaloes, elephants, mastodons, glyptodons, and large predatory forms as wolves, mountain lions giant lions, sabertoothed tigers, and bears. Often several individuals of carnivorous forms, as giant wolves, sabertoothed tigers are associated with a single large ruminant. Discussed by Messrs. Gill, Hay and others.

Notes on the big bears of North America: Dr. C. HART MERRIAM. The speaker commented on the lack of adequate material for a systematic study of these bears. The black bear and allied forms he regarded as constituting a distinct genus from the brown and grizzly bears belonging to the genus Ursus, about forty forms of which could be recognized as inhabiting the North American continent and adjacent islands.

Distribution of game animals in Africa: EDMUND HELLER. Mr. Heller spoke of the life zones and areas of East Africa illustrating the subject with maps, views of topography, and characteristic mammals. The following areas, based mainly upon watersheds, were recognized: West Nile, East Nile, Uganda, East Africa, Abyssinia; and these life zones: Congo Forest, Tropical, Nyika, Highland Veldt, Highland Forest.

M. W. LYON, JR., *Recording Secretary, pro tem.*

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